

We Claim:

1. A reconfigurable measurement system, comprising:  
a computer system comprising a processor and a memory;  
5 wherein the memory stores a measurement program, wherein the measurement program specifies a measurement function;  
wherein the memory also stores a program which is executable to generate a hardware configuration program based on the measurement program; and  
a device coupled to the computer system, wherein the device includes:  
10 a programmable hardware element, wherein the hardware configuration program is operable to be deployed onto the programmable hardware element; and  
one or more fixed hardware resources coupled to the programmable hardware element;  
wherein the hardware configuration program specifies a configuration for the programmable hardware element that implements the measurement function;  
15 wherein the hardware configuration program further specifies usage of the one or more fixed hardware resources by the programmable hardware element in performing the measurement function; and  
wherein, after the hardware configuration program is deployed onto the programmable hardware element, the device is operable to perform the measurement function.  
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2. The reconfigurable measurement system of claim 1,  
wherein the device being operable to perform the measurement function  
25 comprises the programmable hardware element being operable to perform the measurement function in conjunction with the one or more fixed hardware resources.
3. The reconfigurable measurement system of claim 1,

wherein, after the hardware configuration program is deployed onto the programmable hardware element, the programmable hardware element is operable to:

directly perform a first portion of the measurement function; and

invoke the one or more fixed hardware resources to perform a second

5 portion of the measurement function.

4. The reconfigurable measurement system of claim 3,

wherein the hardware configuration program specifies:

the first portion of the measurement function to be performed directly by

10 the programmable hardware element; and

usage of the one or more fixed hardware resources by the programmable hardware element to perform the second portion of the measurement function.

5. The reconfigurable measurement system of claim 1,

15 wherein the one or more fixed hardware resources are operable to provide one or more of:

a control and data path to the computer system;

I/O interfacing to an external system;

optimized hardware elements; and

20 basic operating services.

6. The reconfigurable measurement system of claim 1,

wherein the programmable hardware element is operable to perform one or more of: I/O interfacing, timing and triggering, inline processing, and embedded decision-making.

7. The reconfigurable measurement system of claim 1,

wherein the device further comprises a processor and memory;

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wherein at least a portion of the measurement program is operable to be stored in the memory and executed by the processor.

8. The reconfigurable measurement system of claim 1,  
5 wherein the programmable hardware element includes a processor;  
wherein at least a portion of the measurement program is operable to be executed by the processor.

9. The reconfigurable measurement system of claim 1,  
10 wherein the programmable hardware element is configurable to implement a processor;  
wherein at least a portion of the measurement program is operable to be executed by the processor.

15 10. The reconfigurable measurement system of claim 1,  
wherein the programmable hardware element includes a reconfigurable analog portion;  
wherein at least a portion of the measurement program is operable to be implemented by the reconfigurable analog portion.

20 11. The reconfigurable measurement system of claim 10,  
wherein the reconfigurable analog portion comprises high-level analog components.

25 12. The reconfigurable measurement system of claim 10,  
wherein the reconfigurable analog portion comprises low-level analog components which are operable to be configured to implement high-level analog components.

13. The reconfigurable measurement system of claim 1,  
wherein the memory stores an application development environment for creating  
the measurement program.

5 14. The reconfigurable measurement system of claim 1,  
wherein the device includes one or more slots adapted to receive one or more  
measurement modules;  
wherein the device further includes a measurement module included in a slot of  
the device, wherein the measurement module implements a portion of the measurement  
10 function.

15 15. The reconfigurable measurement system of claim 1,  
wherein the measurement program comprises a graphical program.

15 16. The reconfigurable measurement system of claim 15,  
wherein the graphical program comprises a block diagram portion and a front  
panel portion;  
wherein the program is executable to generate a hardware configuration program  
based on the block diagram portion; and  
20 wherein the computer system is operable to display the front panel portion.

17. The reconfigurable measurement system of claim 1, wherein the  
measurement function comprises one or more of signal acquisition, signal conditioning,  
signal conversion, and measurement analysis.

25 18. The reconfigurable measurement system of claim 1,  
wherein the programmable hardware element is a field programmable gate array  
(FPGA).

THEODORE F. CONLEY  
CONLEY, ROSE & TAYON, P.C.  
ATTORNEYS AT LAW

19. The reconfigurable measurement system of claim 1,  
wherein the computer system is operable to display one or more panels on the  
display while the programmable hardware element in the device executes to perform the  
measurement function on the signal, wherein at least one of the one or more panels  
5 displays the measured signal.

20. The reconfigurable measurement system of claim 1,  
wherein the device includes one or more slots adapted to receive one or more  
measurement modules;

10 wherein the device further includes a measurement module included in a slot of  
the device, wherein the measurement module implements a portion of the measurement  
function.

21. The reconfigurable measurement system of claim 20,  
15 wherein the measurement module includes:  
an input for acquiring a signal; and  
measurement circuitry coupled to the input, wherein the measurement  
circuitry is operable to perform one or more of signal conditioning and signal conversion;  
wherein the device is executable to perform the measurement function on an  
20 acquired signal.

22. The reconfigurable measurement system of claim 20,  
wherein the measurement module further includes:  
interface circuitry, wherein the interface circuitry is operable to provide an  
25 interface for the measurement circuitry;  
wherein the interface circuitry is operable to provide an interface protocol  
describing the interface;  
wherein the programmable hardware element is programmable to interface with  
the measurement module in accordance with the communicated interface protocol; and

wherein the device is operable to perform as one or more of a measurement device and a control device.

23. The reconfigurable measurement system of claim 22,  
5 wherein the device is operable to communicate the provided interface protocol describing the interface to the computer system; and  
wherein the computer system is operable to program the programmable hardware element to implement the interface protocol.

10 24. The reconfigurable measurement system of claim 22,  
wherein the device is a card comprised in a slot of the computer system

15 25. The reconfigurable measurement system of claim 22,  
wherein the device is coupled to the computer system over a network  
26. A reconfigurable control system, comprising:  
a computer system comprising a processor and a memory;

wherein the memory stores a control program, wherein the control program specifies a control function;

20 wherein the memory also stores a program which is executable to generate a hardware configuration program based on the control program; and  
a device coupled to the computer system, wherein the device includes:

a programmable hardware element, wherein the hardware configuration program is operable to be deployed onto the programmable hardware element;

25 one or more fixed hardware resources coupled to the programmable hardware element;  
wherein the hardware configuration program specifies a configuration for the programmable hardware element that implements the control function;

wherein the hardware configuration program further specifies usage of the one or more fixed hardware resources by the programmable hardware element in performing the control function; and

5        wherein, after the hardware configuration program is deployed onto the programmable hardware element, the device is operable to perform the control function.

27.      The reconfigurable control system of claim 26,

wherein the device being operable to perform the control function comprises the programmable hardware element being operable to perform the control function in conjunction with the one or more fixed hardware resources.

10        28.      The reconfigurable control system of claim 26,

wherein, after the hardware configuration program is deployed onto the programmable hardware element, the programmable hardware element is operable to:

15            directly perform a first portion of the control function; and

                invoke the one or more fixed hardware resources to perform a second portion of the control function.

20        29.      The reconfigurable control system of claim 28,

wherein the hardware configuration program specifies:

the first portion of the control function to be performed directly by the programmable hardware element; and

usage of the one or more fixed hardware resources by the programmable hardware element to perform the second portion of the control function.

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30.      The reconfigurable control system of claim 26,

wherein the one or more fixed hardware resources are operable to provide one or more of:

                a control and data path to the computer system;

I/O interfacing to an external system;  
optimized hardware elements; and  
basic operating services.

5           31.     The reconfigurable control system of claim 26,  
              wherein the programmable hardware element is operable to perform one or more  
              of: I/O interfacing, timing and triggering, inline processing, and embedded decision-  
              making.

10          32.     The reconfigurable control system of claim 26,  
              wherein the device further comprises a processor and memory; and  
              wherein at least a portion of the control program is operable to be stored in the  
              memory and executed by the processor.

15          33.     The reconfigurable control system of claim 26,  
              wherein the programmable hardware element includes a processor; and  
              wherein at least a portion of the control program is operable to be executed by the  
              processor.

20          34.     The reconfigurable control system of claim 26,  
              wherein the programmable hardware element is configurable to implement a  
              processor; and  
              wherein at least a portion of the control program is operable to be executed by the  
              processor.

25          35.     The reconfigurable control system of claim 26,  
              wherein the programmable hardware element includes a reconfigurable analog  
              portion; and

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wherein at least a portion of the control program is operable to be implemented by the reconfigurable analog portion.

36. The reconfigurable control system of claim 26,  
5 wherein the reconfigurable analog portion comprises high-level analog components.

37. The reconfigurable control system of claim 26,  
10 wherein the reconfigurable analog portion comprises low-level analog components which are operable to be configured to implement high-level analog components.

38. The reconfigurable control system of claim 26,  
15 wherein the memory stores an application development environment for creating the control program.

39. The reconfigurable measurement system of claim 38,  
20 wherein the device includes one or more slots adapted to receive one or more control modules; and  
wherein the device further includes a control module included in a slot of the device, and wherein the control module implements a portion of the measurement function.

40. The reconfigurable control system of claim 26,  
25 wherein the control program comprises a graphical program.

41. The reconfigurable control system of claim 40,  
wherein the graphical program comprises a block diagram portion and a front panel portion;

wherein the program is executable to generate a hardware configuration program based on the block diagram portion;

wherein the computer system is operable to display the front panel portion.

5        42. The reconfigurable control system of claim 26, wherein the control function comprises one or more of signal acquisition, signal conditioning, signal conversion, and control analysis.

43. The reconfigurable control system of claim 26,  
10 wherein the programmable hardware element is an FPGA.

44. The reconfigurable control system of claim 26,  
wherein the computer system is operable to display one or more panels on the  
display while the programmable hardware element in the device executes to perform the  
control function on the signal, wherein at least one of the one or more panels displays the  
measured signal.

45. The reconfigurable control system of claim 26,  
wherein the device includes one or more slots adapted to receive one or more  
control modules; and  
wherein the device further includes a control module included in a slot of the  
device, wherein the control module implements a portion of the control function.

46. The reconfigurable control system of claim 26,  
25 wherein the control module includes:

an input for acquiring a signal; and  
control circuitry coupled to the input, wherein the control circuitry is  
operable to perform one or more of signal conditioning and signal conversion;

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wherein the device is executable to perform the control function on an acquired signal.

5        47.      The reconfigurable control system of claim 46,  
wherein the control module further includes:  
                interface circuitry, wherein the interface circuitry is operable to provide an  
                interface for the control circuitry;  
                wherein the interface circuitry is operable to provide an interface protocol  
                describing the interface;  
10        wherein the programmable hardware element is programmable to interface with  
the control module in accordance with the communicated interface protocol; and  
                wherein the device is operable to perform as one or more of a control device and a  
control device.

15        48.      The reconfigurable control system of claim 47,  
wherein the device is operable to communicate the provided interface protocol  
describing the interface to the computer system; and  
                wherein the computer system is operable to program the programmable hardware  
element to implement the interface protocol.

20        49.      The reconfigurable control system of claim 47,  
wherein the device is operable to communicate the provided interface protocol  
describing the interface to the computer system; and  
                wherein the computer system is operable to program the programmable hardware  
element to implement the interface protocol.

25        50.      The reconfigurable control system of claim 26,  
wherein the device is a card comprised in a slot of the computer system

51. A method for configuring a device to perform a function, wherein the device includes a programmable hardware element and one or more fixed hardware resources, the method comprising:

5 creating a program, wherein the program represents the function;  
generating a hardware configuration program based on the program, wherein the hardware configuration program specifies a configuration for the programmable hardware element that implements the function, and wherein the hardware configuration program further specifies usage of the one or more fixed hardware resources by the programmable hardware element in performing the function; and

10 15 configuring the programmable hardware element utilizing the hardware configuration program;

wherein, after said configuring, the device is operable to perform the function;

and

wherein said device being operable to perform the function comprises the programmable hardware element being operable to directly perform a first portion of the function, and the programmable hardware element being operable to invoke operation of one or more of the fixed hardware resources to perform a second portion of the function.

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52. The method of claim 51,  
wherein the device comprises a measurement device; and  
wherein the function comprises a measurement function.

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53. The method of claim 51,  
wherein the device comprises a control device; and  
wherein the function comprises a control function.

54. The method of claim 51, further comprising:

the device operating to perform the function, wherein the device operating comprises:

the programmable hardware element directly performing the first portion of the function; and

5 the programmable hardware element invoking operation of one or more of the fixed hardware resources to perform the second portion of the function.

55. The method of claim 54,

wherein the device operating to perform the function comprises:

10 the device acquiring a signal from an external source; and

the programmable hardware element in the device executing to perform the function on the signal.

56. The method of claim 51, further comprising:

15 the device acquiring a signal from an external source after said configuring; and

the programmable hardware element in the device executing to perform the function on the signal.

57. The method of claim 56,

20 wherein, in performing the function, the programmable hardware element performs one or more of: I/O interfacing, timing and triggering, inline processing, and embedded decision-making.

58. The method of claim 56,

25 wherein the programmable hardware element in the device executing to perform the function on the signal comprises:

the programmable hardware element directly performing the first portion of the function; and

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the programmable hardware element invoking operation of the one or more of the fixed hardware resources to perform the second portion of the function.

5           59.     The method of claim 58,  
wherein the one or more fixed hardware resources performing the second portion of the function comprises one or more of:

10                 providing a control and data path from the device to the computer system;  
                       providing I/O interfacing between the device and an external system;  
                       providing optimized hardware elements for the device; and  
                       providing basic operating services for the device.

15           60.     The method of claim 51,  
wherein the programmable hardware element includes a reconfigurable analog portion, the method further comprising:

15                 the reconfigurable analog portion executing a portion of the program to perform a third portion of the function.

20           61.     The method of claim 60,  
wherein the reconfigurable analog portion comprises high-level analog components.

25           62.     The method of claim 60,  
wherein the reconfigurable analog portion comprises low-level analog components which are operable to be configured to implement high-level analog components.

63.     The method of claim 51,  
wherein the device further comprises a processor and memory, wherein a portion of the program is operable to be stored in the memory, the method further comprising:

the processor executing said portion of the program to perform a third portion of the function.

64. The method of claim 51,

5 wherein the programmable hardware element is configured to implement a processor, wherein the device further comprises a memory, and wherein a portion of the program is stored in the memory, the method further comprising:

the implemented processor executing said portion of the program to perform a third portion of the function.

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65. The method of claim 51,

wherein the program comprises a graphical program.

66. The method of claim 65,

15 wherein the graphical program comprises a block diagram portion and a front panel portion;

wherein the program is executable to generate a hardware configuration program based on the block diagram portion; and

wherein the computer system is operable to display the front panel portion.

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67. The method of claim 51, wherein the function comprises one or more of signal acquisition, signal conditioning, signal conversion, and measurement analysis.

68. The method of claim 51,

25 wherein the device is a small form factor device with dimensions less than about 2" by 2" by 1".

69. The method of claim 51,

wherein the device includes an interface, wherein the interface comprises one or more of an Ethernet, Internet, USB, or FireWire interface.

70. The method of claim 51,  
5 wherein the device includes one or more slots adapted to receive one or more measurement modules; and  
wherein the device further includes a measurement module included in a slot of the device, the method further comprising:  
the measurement module implementing a third portion of the function.

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71. The method of claim 70,  
wherein the measurement module includes:  
an input for acquiring a signal; and  
measurement circuitry coupled to the input, wherein the measurement  
15 circuitry is operable to perform one or more of signal conditioning and signal conversion;  
the method further comprising:  
the measurement module acquiring the signal via the input; and  
the measurement circuitry performing one or more of signal conditioning and signal conversion on the acquired signal, thereby producing a conditioned signal;  
20 the measurement module sending the conditioned signal to the device; and  
the device performing the function on the conditioned signal.

72. The method of claim 70,  
wherein the measurement module further includes interface circuitry for  
25 providing an interface for the measurement circuitry, the method further comprising:  
the interface circuitry providing an interface protocol describing said interface; and  
programming the programmable hardware element to interface with the measurement module in accordance with the communicated interface protocol.

73. The method of claim 72,  
wherein said interface protocol describing the interface is provided to a computer  
system coupled to the device; and  
5 wherein said programming the programmable hardware element to implement the  
interface protocol is performed by the computer system.

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74. The method of claim 51,  
wherein the device is a card comprised in a slot of a computer system.

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75. The method of claim 51,  
wherein the device is coupled to a computer system over a network.

76. The method of claim 51, further comprising:  
displaying one or more panels on a display while the programmable hardware  
element in the device executes to perform the function on the signal, wherein at least one  
of the one or more panels displays the measured signal.

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77. The method of claim 51,  
wherein the programmable hardware element is an FPGA.

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78. A reconfigurable measurement system, comprising:  
a computer system comprising a processor and a memory;  
wherein the memory stores a program, wherein the program specifies a  
function;  
wherein the memory also stores a program which is executable to generate  
a hardware configuration program based on the program; and  
a device coupled to the computer system, wherein the device includes:

a programmable hardware element, wherein the hardware configuration program is operable to be deployed onto the programmable hardware element; and

one or more fixed hardware resources coupled to the programmable hardware element;

5 wherein the hardware configuration program specifies a configuration for the  
programmable hardware element that implements the function;

wherein the hardware configuration program further specifies usage of the one or more fixed hardware resources by the programmable hardware element in performing the function; and

10 wherein, after the hardware configuration program is deployed onto the programmable hardware element, the device is operable to perform the function.

79. The reconfigurable measurement system of claim 78,  
wherein the device being operable to perform the function comprises the  
15 programmable hardware element being operable to perform the function in conjunction  
with the one or more fixed hardware resources.

80. The reconfigurable measurement system of claim 78,  
wherein, after the hardware configuration program is deployed onto the  
20 programmable hardware element, the programmable hardware element is operable to:  
directly perform a first portion of the function; and  
invoke the one or more fixed hardware resources to perform a second  
portion of the function.

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81. A memory medium comprising program instructions which are executable to configure a device to perform a function, wherein the device includes a programmable

hardware element and one or more fixed hardware resources, wherein the memory medium stores:

- a program, wherein the program specifies the function;
- a hardware configuration program generated based on the program, wherein the
- 5 hardware configuration program specifies a configuration for the programmable hardware element that implements the function, and wherein the hardware configuration program further specifies usage of the one or more fixed hardware resources by the programmable hardware element in performing the function; and
- 10 a deployment program executable to deploy the hardware configuration program onto the programmable hardware element;
- wherein, after deployment, the device is operable to perform the function, wherein said device being operable to perform the function comprises the programmable hardware element being operable to directly perform a first portion of the function, and the programmable hardware element being operable to invoke operation of one or more of the fixed hardware resources to perform a second portion of the function.
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- 82. The memory medium of claim 81,
  - wherein the function comprises a measurement function; and
  - wherein the hardware configuration program specifies a configuration for the
  - 20 programmable hardware element that implements the measurement function.
- 83. The memory medium of claim 81,
  - wherein the function comprises a control function; and
  - wherein the hardware configuration program specifies a configuration for the
  - 25 programmable hardware element that implements the control function.
- 84. The memory medium of claim 81, wherein the hardware configuration program comprises:

a first portion which is executable in the programmable hardware element to directly perform a first portion of the function; and

a second portion which is executable in the programmable hardware element to invoke operation of one or more of the fixed hardware resources to perform the second portion of the function.

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wherein at least a portion of the program is operable to be stored in the memory for execution by the processor to perform a third portion of the function.

5           90.     The memory medium of claim 81,  
              wherein the program comprises a graphical program.

91.     The memory medium of claim 90,  
              wherein the graphical program comprises a block diagram portion and a front panel portion;  
10           wherein the deployment program is executable to generate a hardware configuration program based on the block diagram portion; and  
              wherein the computer system is operable to display the front panel portion.

15           92.     The memory medium of claim 81, wherein the function comprises one or more of signal acquisition, signal conditioning, signal conversion, and measurement analysis.

20           93.     The memory medium of claim 81,  
              wherein the device is a small form factor device with dimensions less than about 2"  
              by 2" by 1".

25           94.     The memory medium of claim 81,  
              wherein the device is a card comprised in a slot of a computer system.

95.     The memory medium of claim 81,  
              wherein the device is coupled to a computer system over a network.

96.     The memory medium of claim 81, further comprising:

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a display program for displaying one or more panels on a display while the hardware configuration executes in the programmable hardware element in the device to perform the function on an acquired signal, wherein at least one of the one or more panels displays the acquired signal.

5

97. The memory medium of claim 81,  
wherein the programmable hardware element is an FPGA.

98. A memory medium comprising program instructions which are executable  
10 to configure a device to perform a function, wherein the device includes a programmable  
hardware element and one or more fixed hardware resources, wherein said program  
instructions are executable to perform:

creating a program, wherein the program implements the function;  
generating a hardware configuration program based on the program, wherein the  
15 hardware configuration program specifies a configuration for the programmable  
hardware element that implements the function, and wherein the hardware configuration  
program further specifies usage of the one or more fixed hardware resources by the  
programmable hardware element in performing the function; and  
deploying the hardware configuration program onto the programmable hardware  
20 element;

wherein, after said deploying, the device is operable to perform the function,  
wherein said device being operable to perform the function comprises the programmable  
hardware element being operable to directly perform a first portion of the function, and  
the programmable hardware element being operable to invoke operation of one or more  
25 of the fixed hardware resources to perform a second portion of the function.

99. The memory medium of claim 98,  
wherein the function comprises a measurement function;

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wherein the hardware configuration program specifies a configuration for the programmable hardware element that implements the measurement function.

100. The memory medium of claim 98,  
5 wherein the function comprises a control function;  
wherein the hardware configuration program specifies a configuration for the programmable hardware element that implements the control function.

101. The memory medium of claim 98,  
10 wherein the hardware configuration program comprises:  
a first portion which is executable in the programmable hardware element to  
directly perform a first portion of the function; and  
a second portion which is executable in the programmable hardware element to  
invoke operation of one or more of the fixed hardware resources to perform the second  
15 portion of the function.

102. The memory medium of claim 98, wherein said program instructions are  
further executable to perform:  
receiving user input specifying the function, wherein said program is created  
20 based on the user input.

103. The memory medium of claim 98, wherein the program comprises a  
graphical data flow program.

25 104. A programmable hardware element which is configured with a hardware  
configuration program to perform a function, wherein the hardware configuration  
program comprises:  
a first portion which is executable in the programmable hardware element to  
directly perform a first portion of the function; and

a second portion which is executable in the programmable hardware element to invoke operation of one or more of the fixed hardware resources to perform the second portion of the function.

5        105. The programmable hardware element of claim 104,  
wherein the hardware configuration program further includes:  
            a third portion for configuring a reconfigurable analog portion in the  
programmable hardware element.

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